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Dutch Disease and Exchange Rate in Algeria: An Empirical Investigation

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Abstract

This study seeks to examine the Dutch disease theory and assess its impact on the equilibrium real exchange rate's performance (*Lreer)* in Algeria from 1990 to 2016 since it is, highly, dependent on oil revenues. To do so, we first provide a literature review for Dutch disease and its relationship with REER. Then, in order to test our two underlying hypotheses, we proceed to perform the Auto Regressive Distributed Lag (ARDL) model that helps in detecting the long-run cointegrating relationship. In addition, we apply the Ordinary Least Square (OLS) and the Error Correction models for the examination of both the long and the short-run relationships. As expected, our estimates suggest that the long-run performance of the real exchange rate depends, essentially, having significant positive signs, on the technological progress (*Lprod*), government spending (*Lgs*), capital flows (*Lcf*), informal employment (*Lemp*) and terms of trade (*Ltot*). However, oil rent (*Loilrent*) and trade openness ($Lopen_1$) have significant negative impacts on the *Lreer*. This is not in line with a priori expectations, i.e. the failure to meet the main condition for the Dutch disease presence (Spending effect) as well as the resource movement effect captured by the share of employment in informal sector cannot be confirmed. Therefore, although the industrial and agricultural sectors are deteriorating, there is no evidence of Dutch disease in Algeria. Then the short-run elasticities of variables were detected to be highly significant. The rise in all variables caused the real exchange rate to appreciate, but the increase in the first lagged variables of *Lemp, Ltot, Lcf* and *Lgs* led to a real depreciation. Thus, having some Dutch disease symptoms does not provide a Dutch disease evidence. Accordingly, the research objective has been achieved and hypotheses have been verified.

Keywords: Equilibrium Real Exchange Rate, Oil Revenues, Dutch Disease, ARDL, Algeria.

JEL Classification: F16, E62, F31, C51, F21.

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Introduction

The natural resource durability and profitability problems are not recent. There are several oil countries that exploited the natural resources since the sixties for the benefit of large and enormous industrialization policies. However, the results did not show any advantage, but negative effects of income on the growth, such as de-industrialization and international competitiveness losses in particular in oil countries, which evoked the reconsideration of the policies to deal with these effects. The Algerian economy has the tenth-greatest natural gas reserves, and sixteenth-greatest oil reserves as considered sixth-biggest gas exporter worldwide. Therefore, the Algerian economy is one of the most dependent economies on exporting oil, gas and related outcomes that dominate the economic development process whose strategies cannot be analysed without returning to the oil sector reinforced with each rise of their prices. Indeed, after the crisis of 1986, many dangerous indicators on the local economy appeared following the disorders on the macroeconomic level, particularly since 2007. In spite of the significant exchange reserves derived from the high oil prices that reached USD 113.3 billion in 2016 (against USD 194 billion in 2013 according to the World Bank), and the decline of more than 40 per cent since 2013, the economy of Algeria and, particularly, the industrial sector showed neither great change nor improvement. In fact, the natural resource abundance and lack of non-hydrocarbon industries forced the Algerian economy to be strongly dependent on income derived from oil production (oil industry) in order to satisfy its needs of goods, services and even of capital. This phenomenon has been reflected in a strong ratio of oil resources, generating more than 96 per cent of total export earnings in 2017 and roughly, 60 per cent of the budget revenues, as it is responsible for 30 per cent of GDP. However, diversification of manufacturing industries has been little developed since the independence in 1962, despite the high volume of incomes derived from oil and gas, that is shown by a growth rate of 2.9 per cent in 2015 according to IMF, with a slight decrease compared to 2014 (3.8 per cent); while the non-hydrocarbon GDP growth reached 1.3 per cent in 2017 (against 5 per cent in 2015) under the expenditure effects as a result of the declining oil prices since 2014. This made the government under pressure to reduce spending, and its ability to make use of the state-driven growth to dispense the rents, and fund the generous public subsidies. In addition, the Algerian government reduced the fiscal deficit in 2016, while the inflation increased from 4.8 per cent in 2015 to 7.7 per cent in 2017.

Literature Review

A vast growing body of literature has inspected the relative importance of exchange rate that is still a subject to considerable debate. Recently, investigators have confirmed the role that capital flows, derived mainly from the new resource discoveries-especially oil thanks to its strategic role in all economies or from the appreciation of their prices, play in appreciating the exchange rate, causing the well-known 'Dutch disease' phenomenon and examined its effects that make economies, particularly those of oil-exporting countries, suffer big problems influencing their production and industrialization structures. Indeed, the strong dependence of oil receipts has its advantages and its disadvantages. In this regard, certain literature affirms that the oil revenues and the capital inflows play a crucial role in appreciating the real exchange rate, which in turn leads to the competitiveness loss, and results in disruptive effects on the industrial structure, and, thus, a delay of economic growth. For example, *Touitou & al.(2019)* proceeded to, empirically, determine the link between the exchange rate and the economic growth in Algeria using the Vector Auto-Regressive model (VAR), and their findings for the period 1990-2015 revealed a negative association between the real exchange rate and the economic growth via the petroleum taxation, similarly to the study of *Kakanov & al.(2018)* who asked whether this association in twenty-four oil exporters including Algeria, relies on the institutional and the macroeconomic environment from 1982 to 2012. On the basis of the used error correction model's findings (ECM), they affirmed the existence of the resource curse, and that a more flexible exchange rate affects negatively the long-run growth, but they found no evidence that the higher quality institutions could dwindle it. However, a more stable exchange rate could play a key role and protect the oil-dependent economies against oil price shocks in addition to enhance the economic development.

A further study aimed to examine the dynamic relationship between the fluctuations of real oil revenues and the economic growth in Algeria from 1960 to 2015. The authors applied the Johansen multivariate cointegration approach, and they found a long-run relationship between real oil revenues, industrial growth and real GDP in Algeria. Then, they concluded that, although oil revenues represent its main source of income, Algeria cannot rely on the natural resources, which are neither a blessing nor a curse, to sustain its economy, particularly, as its oil sector is not labour-intensive, that is, creating few jobs. Therefore, it faces a challenge in reducing this dependency via the diversification of income sources. *Laourari & Gasmi(2016).* For the same purpose, *Moayad & al.(2018)* applied a bivariate VAR Model on annual data from 1970 to 2017, and they found a strong relationship between the oil revenues and growth in Saudi Arabia in both long and short-run.

Whereas *Akinyemi & al.(2017)* tried to examine the joint impact of oil revenues with real exchange rate on the economic growth in Nigeria during the period from 1981-2015, using the OLS method. The results revealed that both exchange rate and oil revenues have a complementary role in affecting the economic growth. An earlier study of *Shehu(2009)* investigated similar issues through applying Johansen VAR-based cointegration technique and vector error correction model (VECM) on quarterly data over a different period (1986-2007). As a result, the author found a bidirectional causality from the real exchange rate to the real GDP and a unidirectional causality from the oil prices to the real GDP and vice versa. Hence, both oil price shock and exchange rate appreciation have a positive impact on the real economic growth. *Oluwatomisin & al.(2014)* used the same previous technique to analyse the effects of oil price, interest rate and external reserves on the Nigerian exchange rate volatility between 1970 and 2010, and based on their findings, they provided evidence of the exchange rate susceptibility to changes in oil price. The three previous authors agreed that the government of Nigeria should look for a new way to diversify its economy in order to minimize its high reliance on oil products, and guard against oil price shocks and exchange rate volatility. This, accordingly, would enhance the employment and the economic growth through investing in new productive sectors, and reducing the contribution of oil products to the foreign exchange earnings.

Another study used the panel co-integration techniques by means of the dynamic least squares' technique in a set of 48 industrialized and emerging countries, from 1980 to 2004. The results demonstrated that the real exchange rate appreciates, significantly, at the equilibrium level when the government consumption increases, and the terms of trade improve, the price controls are fewer or, but weakly, when the country assembles the net foreign assets, while RER appreciation, induced by the rise in the productivity differentials between the tradable and non-tradable sectors, is relatively small although statistically significant. However, a country that decides to liberalize its foreign trade registers a depreciation of its equilibrium RER. The author, then, highlights a structural break in the period after 1973. *Ricci & al.(2008).*

Without any doubt, the exchange rate is determined by the interaction between supply and demand for the foreign currencies, and thus, since it represents a strategic macroeconomic price, it is crucial to determine if the its level is compatible with the equilibrium or not to assess the extent to which the economy could be affected by the Dutch disease. Among the studies that treat this issue, *Sakib & Muntasir(2017)* who aimed to identify the movements of the Bangladesh's real exchange rate due to the remittance inflow over the period of 1980 to 2013, and whether they result in Dutch disease using the bounds testing approach (ARDL). The main findings provided evidence of a negative correlation between the two variables. These movements nonetheless were not seen as a Dutch disease symptom.

Mouhamadou & Tabarraei (2009) explained, theoretically and empirically, the effect of capital inflows, in particular the foreign direct investment, the foreign aid and the remittances, on the real exchange rate movements of the developing countries using time series and panel data. The results illustrated that the real fundamentals represent the key driving forces behind RER movements in LDCs, but not the capital inflows. *The Balassa–Samuelson effect*, only, accounts for 57 per cent of RER fluctuations, while capital inflows account for 19 per cent of them, thus, the Dutch disease theory is not denied, but its effect on RER is minor. However, *Magud & Sosa (2010)* concluded, on the one hand, that Dutch disease exists and results in the appreciation of the real exchange rate. As reported by them, on the one hand, there was a factor reallocation, and the production passed far from manufacturing, and on the other hand, the exchange rate fluctuations slowed down and reduced the economic growth.

Lartey (2008), asked whether the Dutch disease effects due to the capital inflows, should be dealt with by the monetary policy. After elaborating a dynamic stochastic general equilibrium modelling (DSGE) in Argentina and the Philippines during the 1990s, the results showed that, when the monetary policy is geared towards maintaining the nominal exchange rate fixed, the increase in the capital flows results in Dutch disease. However, when it follows *Taylor*'s rule of interest rates, generalized with either the nominal or the real exchange rate, the effects of the Dutch disease do not occur. In short, they do under the system of a fixed nominal exchange rate. In the same line, *Benkhodja (2011)* compared the impact of the windfalls and the boom on the four economic sectors of an oil-exporting country, and their social consequences. Then, he analysed how the monetary policy should be carried out to protect the economy against the major impact of shocks, namely, Dutch disease. He found that the Dutch disease effect arises after the resource movement and the spending effects in the following cases: flexible wages and prices in both the windfall and the boom cases; rigid prices and flexible wages exclusively in the case of a fixed exchange rate. However, in the case of a flexible exchange rate, the Dutch disease effect can be avoided under rigid prices and flexible wages. While *Saborowski(2009)* based on annual data for 85 countries during the period 1995–2006, argued that developing an active and deep financial sector can undermine the link between the real appreciation of the exchange rate and the capital inflows whose impact can be highly reduced by making use of a more flexible exchange rate.

Although the empirical studies of Dutch disease and its effect on exchange rates and economic growth are generally available, the econometric studies of this phenomenon in Algeria are few. For instance, *Abdlaziz & al.(2018)* aimed to examine the long-term relationship between oil price and real exchange rate in 25 oil-exporting countries, including Algeria, as to investigate their effects on agriculture. The authors relied on the OLS, the Dynamic Ordinary Least Squares (DOLS) and the pooled mean group methods. The result showed a significant negative impact of both oil price and exchange rate on the agricultural value added, indicating the Dutch disease existence and the de-agriculturalization in the oil-exporting economies. For the same purpose, *Apergis & al.(2014)* applied the Panel co-integration and causality tests in addition to the two-step System (GMM), on annual data on the Middle East and North African oil-producing countries (MENA) during the period 1970-2011. They, also, found a negative long-term association between the oil rents and the agriculture value-added with a rather slow rate of short-term adjustment of this later back to equilibrium after a boom in oil rents. These results imply that the booming oil sector is associated with a contraction of the agricultural sectors in the long-term. Thus, this is, probably attributable to a resource movement effect from the other economic sectors to the booming oil sector, and serves as an evidence of the Dutch disease impact in MENA countries. From another point of view, *Rickne(2009)* who aimed to reconcile the diverse empirical evidence related to the co-movements of the currencies' real exchange rates with the oil price in thirty-three oil-exporting countries, including Algeria between 1985 and 2005, using political-economic models of budgetary spending, pointed out that these co-movements are conditional upon legal political system. In addition, the currencies of countries with powerful legal systems and bureaucracies are less influenced by the oil price fluctuations, and the countries with sufficiently powerful institutions can prevent the resource curse related the volatile real exchange rate. These results imply that the robust institutional setup can hinder the country from catching Dutch disease via a volatile real exchange rate. The favourable institutional characteristics in Canada, Norway or Saudi Arabia result from the lack of strong positive price effects.

Chekouri & al.(2013) investigated the Dutch Disease evidence in Algeria and its impact on the economy from 1963 to 2008. The results revealed that the Algerian economy is obviously affected by this disease: the growth of manufacturing slowed down, and the agricultural sector showed a very weak performance, while the service sector, to which the employment shifted, performed well. According to the authors, the Algerian government frequently failed to avoid problems regarding the resource abundance or the resource price boom. However, according to *Derbal & Dekkiche (2011) who* focused on the resource movement and the real exchange rate, concluded that if some Dutch disease symptoms exist, this does not mean the existence of Dutch disease, so that the Algerian economy is not affected by this phenomenon. As well, *Djoufelkit (2008)* in her impressive analysis, the key research was whether Algeria will learn from previous oil shocks and use the new wealth to diversify its economy by promoting the development of the mentioned sector. As claimed by her, two main transmission channels exist between the shock resources and the economic growth. The first channel is direct, and occurs via the impact of natural wealth on the tradable sector competitiveness through the real exchange rate appreciation (Dutch disease). Yet, this channel is not engaged in the case of Algeria since the real exchange rate follows a downward trend and even though the terms of trade continue to increase. The second channel is indirect and occurs via the impact of these revenues on the incentives for economic actors to engage in the entrepreneurial activities.

Data Sources and Description of Variables

Data of annual time series for the period 1990–2016 are used in this research to perform the econometric estimations of the equilibrium real exchange rate, and to investigate whether its performance has been affected by the Dutch disease in Algeria using seven variables. The study is limited to this period due to the lack of some available, reliable data, and the difficulty of measuring or calculating other data, however, it is considered enough. The data have been collected from different sources, namely, International Monetary Fund IMF, the World Bank, and Algeria's Office for National Statistics ONS. In addition, different reports, published by the IMF and ONS have been used to supplement the data.

The real exchange rate's yearly index (2010 = 100) values, introduced by IMF database, were considered. The data on informal employment have been extracted from the National Office of Statistics (ONS) for 1992 and from 1997 to 2016, while the rest of employment data were obtained from an economic research because of the lack of data. *Yahiaoui (2016).* Oil Rent, Capital Flows, Government Spending (all expressed as a percentage of constant GDP) and Productivity were calculated based on the World Bank database, likewise the trade openness and terms of trade.

Methodology

To examine the relationships between the focused variables, this paper employs the Auto-Regressive Distributed Lag Model (ARDL), suggested by *Pesaran & al.(2001)* for the co-integration investigation (time series data) and the error correction (short-term) analysis. It is argued that ARDL has several advantages over conventional *Johansen* co-integration techniques. It is, statistically, a more significant approach for determining integrating relationships in small samples, while the *Johansen* co-integration techniques still require large data samples for the purposes of validity. A further advantage of the ARDL is that, while other co-integration techniques require all of the regressors to be integrated of the same order, the ARDL can be applied when the regressors are: I (1) and I (0) i.e. mixed. The major advantage of this approach lies in its identification of the co-integrating vectors where multiple co-integrating vectors exist. The ECM can be derived from the ARDL model through a simple linear transformation that integrates short-run adjustments with long-run equilibrium without losing long-run information. The associated ECM model takes enough lags to capture the data generating process in general to specific modelling frameworks. The following equation is modelled.

$$Reer_t = \beta_0 + \beta_1 Emp_t + \beta_2 OilRent_t + \beta_3 ToT_t + \beta_4 Prod_t + \beta_5 Open_{-1_t} + \beta_6 Cf_t + \beta_7 Gs_t + \varepsilon_t \dots\dots\dots\dots (1)$$, where:

β_0	The intercept;
$\beta_0, \beta_1, \dots \beta_i$	The coefficients; i = 0, 1, 2… I+1
Reer	The Real Effective Exchange Rate (Consumer Price Index 100 = 2010);
Emp	Informal Employment (as a percentage of the total employment);
Oilrent	Oil Rent (as a percentage of GDP);
Tot	Terms of Trade (Index 100 = 2010);
Prod	Productivity (proxied by real GDP per capita in USD);
$Open_{-1}$	Trade Openness (as a percentage);
Cf	Capital Flows (as a percentage of GDP);
Gs	Government Spending (as per cent of GDP); and
ε	The error term.

For the estimation purpose, as we mentioned previously, we make use of the variables in the natural logarithm-form to assess the significance of the association among the macroeconomic variables, thus, the equation (1) can be represented by the following logarithmic reduced form:

$$Lreer = \beta_0 + \beta_1 Lemp + \beta_2 Loilrent + \beta_3 Ltot + \beta_4 Lprod + \beta_5 Lopen_{-1} + \beta_6 Lcf + \beta_7 Lgs + \varepsilon_t \dots\dots\dots\dots (2)$$

Descriptive Statistics of the Series

It is always necessary and essential to run summary statistics before engaging any regression analysis because we need to understand the central tendency and spread of the variables. Table 1 below demonstrates the descriptive statistics of the raw data that we are working with, in this study from 1990 to 2016.

Table 1: Summary of Descriptive Statistics

	Reer	*Emp*	*Oilrent*	*Tot*	*Prod*	$Open_{-1}$	*Cf*	*Gs*
Mean	116.870	0.3010	13.564	0.624	9679.9	0.244	4.792	0.160
Median	105.000	0.358	12.900	0.512	7056.7	0.229	4.738	0.163

Maximum	223.000	0.456	23.210	1.302	44045	0.367	6.839	0.184
Minimum	96.000	0.120	4.940	0.183	3589.8	0.167	1.789	0.130
Std. Dev	26.489	0.120	5.452	0.376	8988.9	0.064	1.409	0.012
Skewness	2.593	-0.153	0.292	0.531	2.506	0.566	-0.270	-0.313
Kutosis	10.693	1.337	1.905	1.865	9.3165	1.960	2.321	2.998
Probability	0.000	0.200	0.420	0.257	0.000	0.264	0.655	0.801
Sum	3155.500	8.129	366.230	16.857	261357.9	6.608	129.39	4.342

Source: *Authors' output using Eviews*

Table 1 represents the descriptive statistics of the data used for analysis; the data are weakly skewed for *Emp*, *Cf* and *Gs,* however, they are positively skewed for the rest of the variables, namely *Reer, Oilrent, Tot, Prod* and $Open_1$. According to the kurtosis value, *Reer* and *Prod* variables have positive kurtosis values greater than 3. Thus, they are said to be *leptokurtic* distributions, while *Emp*, *Oilrent, Tot,* $Open_1$, and *Cf* variables have positive kurtosis values fewer than 3, so, they are said to be *platykurtic* distributions. Furthermore, *Jarque-Bera* statistic measures the difference the normal distribution and the skewness and kurtosis. A large *J-B* value indicates that the errors are not normally distributed. If the p-value is less than 5 per cent, we reject the null hypothesis H_0 of normal distribution as for *Reer* and *Prod*, and inversely to the rest of the variables. Based on the previous results, our data should be transformed into logarithmic form.

Testing for Stationary (The Unit Root Tests)

It is very important to test for the variables' stationarity when coping with time series data that are rarely considered to be stationary at the level. This can be realized using the Augmented *Dickey-Fuller* criterion (ADF), *Phillips Perron* criterion (PP), or other tests such as the *Kwiatkowski-Phillips-Schmidt-Shin (KPSS)* criterion… etc. However, to ensure reliable results, the research employs both ADF and PP. The following table shows the calculated t-statistics' values and the corresponding probability p-values, based on both tests.

Table 2: Outcomes of ADF and PP Tests for Unit Root

Variables	ADF without trend		ADF with trend		PP without trend		PP with trend	
	Test statistics		Test statistics		Test statistics		Test statistics	
	At level	1st dif.	At level	1st dif.	At level	1st dif.	At level	1st dif.
Lreer	-1.389*	-9.041***	-6.256***	-4.347***	-1.921*	-11.022***	-6.256***	-23.486***
Lemp	-2.637**	-7.785***	-0.591*	-9.132***	-2.417**	-7.481***	-1.669*	-9.442***
Loilrent	-0.109*	-4.984***	-2.361*	-5.098***	-2.399*	-5.927***	-1.565*	-5.356***
Ltot	-1.557*	-4.554***	-1.295*	-4.554***	-1.589*	-4.653***	-1.392*	-4.543***
Lprod	-4.030***	Not applicable	-4.131***	Not applicable	-3.259***	Not applicable	-4.404***	Not applicable
$Lopen_{\_1}$	-0.921*	-4.781***	-3.198*	-4.919***	-0.921*	-4.781***	-3.206*	-4.949***
Lcf	-1.539*	-3.807***	-3.206*	-4.376***	1.244*	-3.787***	-3.202*	-4.357**
Lgs	-1.079*	-4.045***	-2.788*	-3.859**	-0.892*	-4.042***	-2.659*	-3.866**

*Notes: Asterisk***, **, * indicate the significance levels of 1 per cent, 5 per cent and 10 per cent respectively. ADF is the Augmented Dickey Fuller criterion. PP is Phillips Perron criterion, and both are tests for stationary with and without trend at the level and the first difference.*

Source: *Authors' output using Eviews.*

Table 2 represents that, for both ADF and PP tests, the unit root is checked at the level and at the first difference. *Lprod* seems to be stationary at the level I(0), and the calculated value of t-statistic is greater than the critical one, and its relevant p-value is fewer than 0.05. This means that we accept the null hypothesis H_0. However, all the other variables are stationary at 1 per cent, 5 per cent after the first difference I(1) because the calculated values of t-statistics are fewer than the critical ones, and their relevant p-values are greater than 0.05. Thus, the null hypothesis H_0 is rejected because no trend exists, that is the alternative hypothesis H_1 is accepted. These results are consistent with the econometric theory that assumes that most of the macroeconomic variables are non-stationary at the level, but after the first difference.

Bound Testing Approach

According to the previous analysis, we have only one stationary variable I(0) which is *Lprod*, and seven stationary variables after the 1st difference I(1) which are: *Lreer, Lemp, Loilrent, Ltot,* $Lopen_1$, *Lcf* and *Lgs*. However, we have no variable which is I(2). In such a case the appropriate model is the ARDL whose preconditions are that the dependent variable should be I(1), and no variable should have an integration order of I (2) with a view to empirically analysing the short-run dynamic interactions and the long-run relationships among the mentioned variables. *Pesaran & al.(2001)* Furthermore, this technique is relatively suitable and more effective in the case of small and finite sample data sizes. The model of unrestricted error correction used for the testing the appropriate relationships is given as:

$$\Delta y_t = c + \sum_{i=1}^{p} a_i \Delta y_{t-i} + \sum_{i=0}^{q} \delta_j \Delta x_{j,t-i} + \lambda_1 y_{t-1} + \sum_{j=1}^{m} \beta_j x_{j,t-1} + \varepsilon_t \ldots\ldots\ldots(3),$$ where:

Δ	represents the first difference;
$j = l \ldots m$	m is the number of independent variables;
p	The dependent variable's lag length;
q	The independent variables' lag length;
α_i, $\delta_{j,i}$	The short-run parameters;
c, β_j	The long-run parameters; and
ε_t	The error term.

Now, in order to check the existence of the possible long-term equilibrating relationships among our 8 variables, the equation (3) has to be estimated applying OLS by taking each variable as dependent, then, performing the bound testing; given that the maximum lag order is 2 since the data used in our model is annual while the optimal lags are selected automatically based on the *Akaike information criterion*. Table3 reports the bound testing results:

Table 3: ARDL Bound Testing for the Possible Long-run Equilibrating Relationships

Selected model ARDL	K=6	Dependent Variable	F-Statistics	Decision
(1)	(1, 2, 2, 2, 0, 1, 2, 2)	F_{Lreer} (Lreer | Lemp, Loilrent, Ltot, Lprod, $Lpen_1$, Lcf, Lgs)	4.32	Co-integration
(2)	(2, 2, 2, 2, 2, 1, 2, 2)	F_{Lemp} (Lemp | Lreer, Loilrent, Ltot, Lprod, $Lpen_1$, Lcf, Lgs)	3.20	Inconclusive
(3)	(1, 1, 2, 2, 2, 2, 2, 2)	$F_{Loilrent}$ (Loilrent | Lreer, Lemp, Ltot, Lprod, $Lpen_1$, Lcf, Lgs)	3.62	Inconclusive
(4)	(1, 2, 2, 0, 2, 0, 0, 1)	F_{Ltot} (Ltot | Lreer, Lemp, Loilrent, Lprod, $Lpen_1$, Lcf, Lgs)	4.09	Inconclusive
(5)	(1, 2, 2, 2, 2, 2, 2, 2)	F_{Lprod} (Lprod | Lreer, Lemp, Loilrent, Ltot, $Lpen_1$, Lcf, Lgs)	32.18	Co-integration

(6)	(1, 1, 2, 2, 0, 0, 2, 2)	F_{Lpen_1} (Lpen$_1$ | Lreer, Lemp, Loilrent, Lprod, Ltot, Lcf, Lgs)	2.429	Inconclusive
(7)	(1, 2, 2, 2, 2, 2, 2, 2)	F_{Lcf} (Lcf | Lreer, Lemp, Loilrent, Ltot, Lprod, Lpen$_1$, Lgs)	3.49	Inconclusive
(8)	(2, 1, 2, 2, 2, 0, 1, 2)	F_{Lgs} (Lgs | Lreer, Lemp, Loilrent, Ltot, Lprod, Lpen$_1$, Lcf)	0.58	No Co-integration
		Lower-bound critical value I0	**Upper-bound critical value I1**	
10 per cent		**2.03**	**3.13**	
5 per cent		**2.32**	**3.5**	
1 per cent		2.96	4.26	

Source: *Authors' output using Eviews*

Implying the long-run co-integration relationships among the variables when the regressions are normalized on *Lreer*, *Lemp*, *Loilrent*, *Ltot*, *Lprod*, $Lopen_1$, *Lcf* and *Lgs* variables. Thus, we reject the null hypothesis of no equilibrating relationship in the long–run for the selected models (1) and (5). Both models have the calculated *Wald* F-statistic higher than the upper bound critical value 4.26 at the level of 1 per cent (4.32 and 32.18 respectively). However, for the ARDL selected model (8), no equilibrating relationship exists because its corresponding calculated F-statistic (0.585) is less than the lower bound critical value (2.03). For the calculated F-statistics of the ARDL selected models (2), (3), (4), (6) and (7), the test results are inconclusive. However, based on the Dutch disease theory, we use $Lreer_t$ as a dependent variable. Thus, based on the equation (3), the model to be estimated in this research is presented as follows:

$$\Delta Lreer_t = c + \sum_{i=1}^{p} \alpha_1 \Delta Lreer_{t-i} + \sum_{i=0}^{q} \delta_1 \Delta Lemp_{t-i} + \sum_{i=0}^{q} \delta_2 \Delta Loilrent_{t-i} + \sum_{i=0}^{q} \delta_3 \Delta Ltot_{t-i} + \sum_{i=0}^{q} \delta_4 \Delta Lprod_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta Lopen1_{t-i} + \sum_{i=0}^{q} \delta_6 \Delta Lcf_{t-i} + \sum_{i=0}^{q} \delta_7 \Delta Lgs_{t-i} + \lambda_1 Lreer_{t-1} + \beta_1 Lemp_{t-1} + \beta_2 Loilrent_{t-1} + \beta_3 Ltot_{t-1} + \beta_4 Lprod_{t-1} + \beta_5 Lopen1_{t-1} + \beta_6 Lcf_{t-1} + +\beta_7 Lgs_{t-1} + \varepsilon_t \quad (4)$$

The main practical question, here, is about choosing the appropriate lag length *p* for dependent variable and *q* for the independent variable, and since the data used in our model are annual, the maximum lag orders should be specified at 2 lags. While, *Akaike* Information criterion AIC, *Schwartz* criterion SIC, *Hannan-Quinn* information criterion HQ, or Log Likelihood… etc. are among the well-known criteria for determining the optimum lag length. This latter corresponds to the lowest values of the first three criteria, but corresponds to the highest value of the last criterion. In our study's regression model, we let Eviews automatically select the appropriate lags for both dependent and independent variables based on the *Akaike* criterion regarding its advantages for small and finite sample sizes. The following table shows that one lag is optimal for the dependent variable *Lreer*.

Table 4: Optimal Lag *(p)* for the Dependent Variable *Lreer* based on different criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	19.32353	NA	0.010225	-1.745098	-1.695359	-1.734304
1	35.31885	28.94390*	0.002453*	-3.173223*	-3.073745*	-3.151634*
2	35.33385	0.025718	0.002698	-3.079414	-2.930197	-3.047030

Source: *Authors' output using Eviews*

After regressing Equation (4), F-statistics of *the Wald test* are computed to identify the long-run relationships among the concerned variables. The *Wald test* and the alternative hypotheses are as follows:

H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = \theta_8 = 0$, meaning that no equilibrating relationship exists (F-statistic is fewer than the lower critical value of the bound I0).

H_1: $\theta_1 \neq 0$ or $\theta_2 \neq 0$ or $\theta_3 \neq 0$ or $\theta_4 \neq 0$ or $\theta_5 \neq 0$ or $\theta_6 \neq 0$ or $\theta_7 \neq 0$ or $\theta_8 \neq 0$ meaning that an equilibrating relationship exists. (F-statistic is higher than the upper critical value of the bound |1.) The table below demonstrates the bound-testing results for ARDL (1, 2, 2, 2, 0, 1, 2, 2):

Table 5: The Selected ARDL (1, 2, 2, 2, 0, 1, 2, 2) Bound Testing for Co-integration

Test Statistic	**Value**	**K**
F-statistic	4.32	7
Critical Value Bound		
Significance	**|0 Bound**	**|1 Bound**
10 per cent	2.03	3.13
5 per cent	2.32	3.5
1 per cent	2.96	4.26

Source: *Authors' output using Eviews*

The co-integration analysis suggests that there exists a long-run relationship between the real exchange rate and their identified fundamentals in Algeria. The F-statistic's value of (4.32) is evidently greater than the value of the upper critical bound|1 at the significance level of 1 per cent. This implies that the null hypothesis is rejected; rather we accept the alternative one that an equilibrating relationship exists.

Diagnostic Tests

The model used for testing the long-run relationship is further tested with diagnostic tests for serial correlation, heteroscedasticity, misspecification and stability.

Table 6: Diagnostic Tests for Serial Correlation, *Ramsey*, Heteroscedasticity and Normality

Residual serial correlation- Breush-Godfrey Serial Correlation LM Test			
LM Test statistic	238.9967	Prob.	0.0510
Heteroscedasticity-*Breush-Godfrey* Test			
F-statistic	1.322426	Prob.	0.4079
Obs*R-squared	20.85077	Prob.	0.3451
Scaled explained SS	0.714710	Prob.	1.0000
Model specification – *Ramsey*'s RESET Test			
F-statistic	3.749174	Prob.	0.1528
Normality of residuals - *Jarque Bera* Normality test J-B			
J-B	0.237864	Prob.	0.888

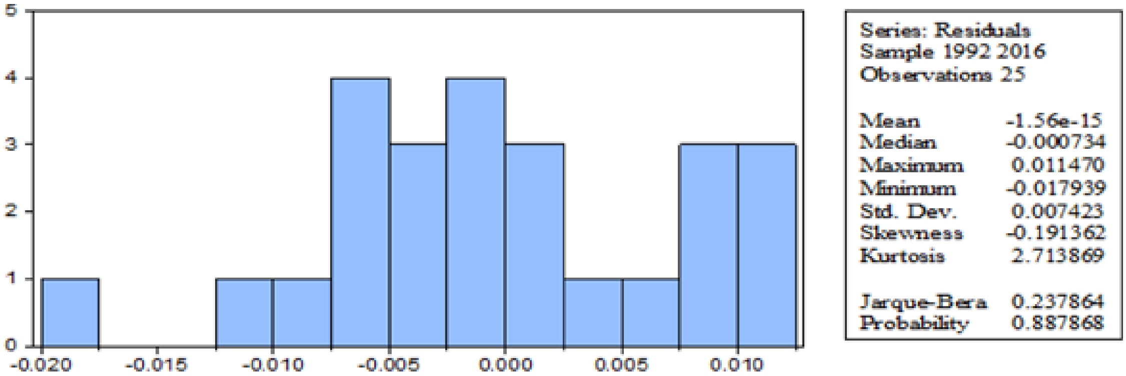
Source: *Authors' output using Eviews*

Tests in Table 6 show no evidence of an autocorrelation, that is, since the null hypothesis is that the residuals are serially uncorrelated, the F-statistic's p-value of 0.051 indicates that we fail to reject it. Therefore, we conclude that we do not have a problem with serial correlation as the residuals are serially uncorrelated. In addition, the null hypothesis of testing for the residuals' homoscedasticity means that the residuals' variance is constant, and the alternative hypothesis (heteroscedastic residuals) means that it is not constant. Thus, since the F-statistic's p-value of 0.407>0.05, as well as the p-value of Obs*R-squared 0.345>0.05, this implies that we cannot accept the alternative hypothesis for the significance level of 5 per cent. We, therefore, conclude that the residuals are homoscedastic at the 5 per cent level of significance.

The F-statistic is, also, reported through the Ramsey-RESET test to check the coefficients on the power of the fitted values from the regression. According to the outputs of this test, we cannot reject the null hypothesis since the p-value is greater than 0.05, that is to say the model has no evidence of misspecification.

The residuals are normally distributed as evidenced by the non-rejection of the normality null hypothesis using Jarque-Bera test since the corresponding p-value is greater than 0.05 (0.888). (See Figure1.)

Figure1: *Jarque-Bera* Test



Authors' Output Using Eviews

In short, the ARDL (1, 2, 2, 2, 0, 1, 2, 2) passed all the diagnostic tests against serial correlation, heteroscedasticity, functional form misspecification, and non-normal errors at 5 per cent level.

Estimation Results (Testing for Long-run and Short-run Coefficients)

The Long-run ARDL Model Estimation

Since the model's variables are co-integrated, the long-run relationship to be estimated takes the following formula.

$$Lreer_t = \lambda_0 + \lambda_1 Lreer_{t-1} + \beta_1 Lemp_{t-1} + \beta_2 Loilrent_{t-1} + \beta_3 Ltot_{t-1} + \beta_4 Lprod_{t-1} + \beta_5 Lopen1_{t-1} + \beta_6 Lcf_{t-1} + +\beta_7 Lgs_{t-1} \ldots\ldots\ldots (5)$$

In order to determine the long-run relationships between the variables, equation (5) is estimated by the ARDL model using their optimal lags that were previously selected based on the *Akaike* information criterion (AIC). The results of the estimated ARDL (1, 2, 2, 2, 0, 1, 2, 2) obtained by normalizing on the real exchange rate (*Lreer$_t$*), are reported in the following Table:

Table 7: Unrestricted Estimates of the Long-run Coefficients.
ARDL (1, 2, 2, 2, 0, 1, 2, 2) Selected based on the *Akaike* Information Criterion

ARDL (1, 2, 2, 2, 0, 1, 2, 2) selected based on AIC. The dependent variable is Lreer				
Regressors	**Coefficient**	**Standard Error**	**Absolute t-statistics**	**Prob.**
C	-6.153223***	0.269934	-22.795270	0.0000
LEMP	0.310280***	0.056401	5.501337	0.0027
LOILRENT	-0.219171**	0.063869	-3.431576	0.0186
LTOT	0.221987***	0.054551	4.069374	0.0096

LPROD	1.045554***	0.120416	8.682867	0.0003
LOPEN-$_1$	-0.179579**	0.067223	-2.671402	0.0443
LCF	0.849618***	0.141085	6.022029	0.0018
LGS	0.891052***	0.127694	6.978047	0.0009
	= 0.62	**F-Stat. F = 3.05**	**Prob. F (0.11)**	**DW= 2.12**

*Notes: The Model selection method: AIC, Maximum dependent lags=1 (Automatic selection). Asterisk***, **, * indicate the coefficients' significance levels of 1 per cent, 5 per cent and 10 per cent respectively.*

Source: *Authors' output using Eviews*

The long-run results of the estimated ARDL co-integration model (1, 2, 2, 2, 0, 1, 2, 2), selected automatically by *the Akaike* information criterion (AIC) out of 512 models are reported in Table 7. They show that the model fits very well at 2 = 0.92, that is 92 per cent of the variations in the real exchange rate are explained by the changes in *Lemp, Loilrent, Ltot, Lprod,* $Lopen_1$, *Lcf* and *Lgs*. The results also suggest that the relationship between the dependent variable and independent ones is not spurious because F-statistic's value for the significance of the determination coefficient is reaching 3.05 at the 10 per cent level of significance. The DW generally, tells us about the error autocorrelation, but in this case, it is not useful because the model is performed by applying more than 1 lag. Furthermore, the table reports the feedback coefficient estimates and their corresponding t-statistics. All the variables in the model exert significant long-term influences on the long-run real exchange rate, implying that, the latter is largely determined by *Lemp, Loilrent, Ltot, Lprod,* $Lopen_1$, *Lcf* and *Lgs* in Algeria. According to the estimated results shown in the previous table, the equation (5) becomes:

$$Lreer = -6.1532 + 0.3103 * Lemp - 0.2192 * Loilrent + 0.2219 * Ltot + 1.0456 * Lprod - 0.1796 * Lopen_1 + 0.8496 * Lcf + 0.8911 * Lgs \ldots\ldots (6)$$

The resulting coefficients from the co-integration equation excluding those of *Loilrent* and *Lemp*, are in line with the economic theory, that is, the estimated coefficients have the expected signs and are highly significant.

Lemp is positively associated with *Lreer*, suggesting that a 10 per cent increase in the share of employment in the informal sector results in a 3.1 per cent increase in the long-run real exchange rate. This result could be interpreted by the loss of competitiveness in the manufacturing sector leading to a shift of labour to the non-tradable sector, informal one here. However, this result is not enough to confirm the resource movement effect, especially in the absence of full employment of the labour force as assumed by the Dutch disease theory.

Loilrent has a highly significant negative association with *Lreer*, indicating that a 10 per cent improvement in oil rent following either raised oil prices or new discoveries, depreciate the real exchange rate by almost 2.2 per cent. The sign of Oil Rent is unexpected, particularly for a high commodity exporting country like Algeria, therefore, the economy of the latter does not exhibit the major symptom of the Dutch disease traditional form. This reflects the role of the exchange rate policy in Algeria. The DZD exchange rate is a subject to the will of the national and international economic organizations such as the Central bank of Algeria or IMF, in accordance with their economic policy's strategic objectives and those of the monetary and the financial policies. Shortly, Algeria's real exchange rate does not serve as a channel through which high oil rent or oil prices could affect the economic structure. (The absence of *the spending effect*)

Ltot has a highly significant positive (appreciating) association. A 10 per cent improvement in the terms of trade, results in a 2.22 per cent real exchange rate appreciation in long-run;

implying that *the income effect* is more important than *the substitution effect*. This effect occurs either due to a decrease in import prices, or an increase in export earnings (because of high oil prices in international markets) relative to imports payment following a rise in demand for Algerian currency. Thus, shifting the trade balance into surplus increases the income, and results in a greater spending on NTs and an increase in the price of NTs relative to Ts.

The technological progress sign (*Lprod*), proxied by the real GDP per capita, has a significant positive (appreciating) effect at the significance level of 1 per cent on *Lreer.* A 10 per cent increase in the technological progress leads to a 10.45 per cent real appreciation in the long-run exchange rate. This is in line with economic theory, and confirms the *Balassa-Samuelson* effect. Higher productivity lowers production costs, and thus, the relative prices of tradables (Ts) to non-tradables (NTs), leading to higher wages in the tradable sector, and then, in the non-tradable one due to the labour mobility between them. In order to be able to pay these wages, the producers must adjust the domestic prices of NTs. This tends to increase the general level of the NTs' prices, and ultimately, results in a real appreciation of DZD exchange rate in the long term.

$Lopen_1$ has a statistically significant negative impact on *Lreer*. A 10 per cent increase in the openness, results in a 1.79 per cent decrease in the real exchange rate. This implies that, as Algeria raises its international trade, its local currency depreciates, or in other words, the larger negative trade balance is associated with an over-appreciation of REER. This strongly supports the hypothesis that an improvement in the trade openness causes a real depreciation in exchange rates in order to facilitate the balance of payments correction. This could be due to the reason that increasing Algeria's trade openness or compressing its trade restrictions through raising the imports penetration rate with lower export taxes, signing trade agreements and reducing import tariffs, is instrumental in achieving a competitive long-run real exchange rate.

The *Lcf* variable seems to be a key determinant of Algeria's long-term real exchange rate since it has a significant positive association with *Lreer.* A 10 per cent increase in the capital flows leads to an 8.5 per cent increase in the real exchange rate. This finding suggests that the capital flows are spent on the NTs and confirms the existing literature that the capital flows could induce a real appreciation in the exchange rate which tends to weaken the competitiveness of the economy.

Similarly, the real exchange rate and the government spending *Lgs* have a significant positive association. A 10 per cent increase in the government spending provokes 8.91 per cent increase in the real exchange rate. Such a sign suggests that Algeria's exchange rate experiences a real appreciation indicating a bias towards NTs.

The Error Correction Model ECM (Short-run Estimates)

Since the variables of our model are integrated, this gives support to the use of the ECM.

$$\Delta Lreer_t = c + \sum_{i=1}^{p} \alpha_1 \Delta Lreer_{t-i} + \sum_{i=0}^{q} \delta_1 \Delta Lemp_{t-i} + \sum_{i=0}^{q} \delta_2 \Delta Loilrent_{t-i} + \sum_{i=0}^{q} \delta_3 \Delta Ltot_{t-i} + \sum_{i=0}^{q} \delta_4 \Delta Lprod_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta Lopen1_{t-i} + \sum_{i=0}^{q} \delta_6 \Delta Lcf_{t-i} + \sum_{i=0}^{q} \delta_7 \Delta Lgs_{t-i} + \psi ECT_{t-1} \dots\dots\dots (7)$$

$$\Delta Lreer_t = c + \sum_{i=1}^{p} \alpha_1 \Delta Lreer_{t-i} + \sum_{i=0}^{q} \delta_1 \Delta Lemp_{t-i} + \sum_{i=0}^{q} \delta_2 \Delta Loilrent_{t-i} + \sum_{i=0}^{q} \delta_3 \Delta Ltot_{t-i} + \sum_{i=0}^{q} \delta_4 \Delta Lprod_{t-i} + \sum_{i=0}^{q} \delta_5 \Delta Lopen1_{t-i} + \sum_{i=0}^{q} \delta_6 \Delta Lcf_{t-i} + \sum_{i=0}^{q} \delta_7 \Delta Lgs_{t-i} + \psi ECT_{t-1} \dots\dots\dots (7)$$

Where: Ψ explains the speed of adjustment; and ECT_{t-1} is the error correction term. The estimation results, still based on the AIC criterion, and they are presented in Table 8:

Table 8: Unrestricted Estimates of the Short-run Coefficients.
ARDL (1, 2, 2, 2, 0, 1, 2, 2) Selected based on the Akaike Information Criterion

ARDL (1, 2, 2, 2, 0, 1, 2, 2) selected based on AIC. The dependent variable is *Lreer*				
Regressors	Coefficient	Standard Error	Absolute t-statistics	Prob.
(Lemp)	0.036834*	0.017807	2.068538	0.0934
(Lemp (-1))	-0.302822***	0.023023	-13.153057	0.0000
(Loilrent)	0.093787***	0.022077	4.248095	0.0081
(Loilrent (-1))	0.327929***	0.028406	11.544245	0.0001
(Ltot)	0.076200**	0.023610	3.227510	0.0233
(Ltot (-1))	-0.201444***	0.027643	-7.287378	0.0008
(Lprod)	1.892220***	0.079440	23.819454	0.0000
(Lopen $_{\_1}$)	0.221635***	0.047176	4.698008	0.0053
(Lcf)	0.873096***	0.041768	20.903299	0.0000
(Lcf (-1))	-0.226866***	0.040454	-5.607952	0.0025
(Lgs)	0.299417***	0.064074	4.672977	0.0055
(Lgs (-1))	-1.456235***	0.102631	-14.189040	0.0000
ECT (-1)	-1.838447***	0.080499	-22.838129	0.0000

*Notes: Asterisk ***, **, * denote the coefficients' significance levels of 1 per cent, 5 per cent and 10 per cent respectively.*

Source: *Authors' output using Eviews*

Table 8 represents the short-run parameters (elasticities) of the equilibrium real exchange rate model. As appeared, all the elasticities are statistically significant. Based on the estimated results shown in the previous Table, equation n° 07 becomes:

$$\Delta Lreer = +0.0368 * \Delta(Lemp) - 0.3028 * \Delta\big(Lemp(-1)\big) + 0.0938 * \Delta(Loilrent) + 0.3279 * \Delta\big(Loilrent(-1)\big) + 0.0762 * \Delta(Ltot) - 0.2014 * \Delta\big(Ltot(-1)\big) + 0.2216 * \Delta(Lopen_1) + 1.89221 * \Delta(Lprod) + 0.8731 * \Delta(Lcf) - 0.2269 * \Delta\big(Lcf(-1)\big) + 0.2994 * \Delta(Lgs) - 1.4562 * \Delta\big(Lgs(-1)\big) - 1.8384 * Ect(-1) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (8)$$

Generally, most of the variables bear the expected signs in the short-run, and no variables are found to be insignificant.

In equation (08), the error correction term $ECT_{(-1)}$ is the lagged error correction term that is the one period lagged value of the error terms derived from the long-run equilibrium model. The coefficient of lagged error-correction term is negative and highly significant as expected (-1.84 (0.000)) which confirms our earlier findings concerning the presence of co-integration between the variables, and a long-run causality running from the independent variables to the dependent one *Lreer*. In fact, it represents the gap between the actual values and the long-run equilibrium values of the real exchange rate. This implies that almost 184 per cent of the short-run errors (disequilibrium) due to the previous year's shocks resulted from the change in the explanatory variables could be adjusted back to the long-term equilibrium in a time unit (year). Therefore, the adjustment speed is 54 per cent i.e. about six and a half months (1÷184 per cent). It should be noted that $ECT_{(-1)}$ coefficient should be between (-2) and (-1), indicating that the lagged error correction term causes dampened fluctuations in the real exchange rate. Based on the evidenced results of the short-run model, the coefficient of $ECT_{(-1)}$ is found to be (-1.84). This implies that in lieu of monotonically converging to the equilibrium path immediately, the process of error correction fluctuates around the long-run value in a dampening way, however, once the process is complete, the convergence to the equilibrium path is swift.

On the other hand, the ECM results show that the *Lemp* elasticity stands at (0.0368) at the significance level of 10 per cent, suggesting a positive relationship between the *Lemp* and *Lreer* rate in the short run. A 10 per cent rise in the share of employment in the informal sector, results in a 0.37 per cent appreciation of the real exchange rate.

Based on our estimation results of ECM, the positive coefficients of *Loilrent* and *Loilrent* (-1) with respect (0.094 and 0.328) are highly significant in the statistical term. A 10 per cent increase in the oil rent leads to almost a 0.94 per cent increase in the real exchange rate. Similarly, a 10 per cent increase in the previous year's oil rent leads to a 3.28 per cent increase in the short-run real exchange rate.

In addition, according to the ECM, *Ltot* is positively signed and statistically significant at 5 per cent. A 10 per cent improvement in the terms of trade, leads to nearly a 0.76 per cent appreciation in the real exchange rate. However, the terms of trade of the previous year are negatively signed, but statistically significant at the significance level of 1 per cent. A 10 per cent improvement in the terms of trade, leads to a 2 per cent depreciation in the short-run real exchange rate.

Similarly, the estimated coefficient of *Lprod* (1.89) is positively significant at 1 per cent level indicating that a 10 per cent improvement in the technological progress leads to an 18.9 per cent increase in the short-run real exchange rate.

$Lopen_1$ appears, also, to play a key role in improving the short-run *Lreer*. The trade openness has a significant positive impact on the real exchange rate at the significance level of 1 per cent. A 10 per cent increase in the trade openness leads to a 2.22 per cent appreciation in the real exchange rate.

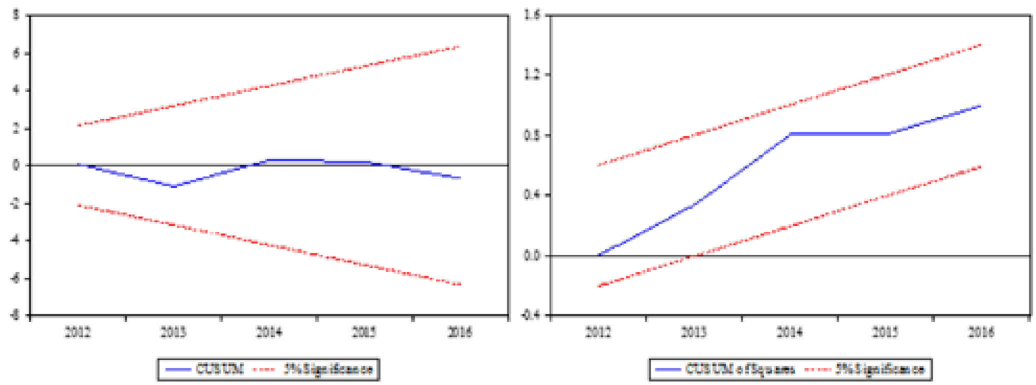
As we expected, the coefficient of *Lcf* bears a significant positive sign (0.87) at the significance level of 1 per cent. A 10 per cent increase in the capital flows appreciates the real exchange rate of approximately 8.73 per cent. This impact, due to increasing demand for NTs and raising their prices given that Algeria's economy is not heavily indebted, is suggesting that most of the capital flows are more directed to be invested in the non-tradable sector in the short-run; while the previous year's capital flows have a significant negative sign (-0.22) at the significance level of 1 per cent indicating that a 10 per cent increase in the capital flows depreciates the short-run real exchange rate by a 2.2 per cent.

Finally, *Lgs* is positively associated with *Lreer* at 1 per cent level of significance, indicating that a 10 per cent increase in the government spending leads to a 2.99 per cent appreciation in the real exchange rate. This result suggests that most of the government spending is directed towards NTs in the short-run, and that the *income effect* is less important than *the substitution effect*. According to the substitution effect, the rise in oil prices leads to increasing the real wages, the government spending and the relative prices NTs. Thus, to a rise in the profitability of the non-tradable sector, and contracting the non-resource tradable goods sector, which hinders the state efforts to enhance the economic activities rather than the hydrocarbon sector. (*Spending effect*.) Indeed, the increase in the Algerian government spending was mainly through three programmes. The plan for supporting economic revitalization 2001–2004 (USD 7 billion), in addition to the growth consolidation programme 2005–2009 (USD 193.8 billion), and the new programme for supporting economic growth 2010–2014 (USD 202.41 billion), while after 2015, the processing budget was estimated at USD 64.3 billion. The previous year's government spending is significantly positive, that is, its increase by a 10 per cent leads to a 14.5 per cent depreciation in the short-run real exchange rate. The model also shows that the past or the lagged values of the studied variables were statistically significant in determining the *Lreer*.

Stability Diagnostic

In addition to the above diagnostic tests, the stability of the estimates in the short and long-run as a requirement for the specified ARDL, is checked through performing both the cumulative sum (CUSUM) and the squares' cumulative sum (CUSUMSQ). The first one helps to show whether the coefficients are changing systematically or not, while the second one is helpful for showing whether the parameters are changing suddenly or not; as shown in the next Figure 2:

Figure 2: Plots of the Cumulative Sum (CUSUM) and the Squares' Cumulative Sum (CUSUMSQ)



Note: The straight line represents the critical bounds test at 5 per cent significance level.

Source: *Authors' Output Using Eviews*

According to those plots, it is evident that the estimated long and short-run parameters estimated by ARDL model and the residual variance are stable, as no structural break exists. The CUSUM and the CUSUMSQ plots (blue lines) are not falling outside the critical bounds of the 5 per cent level (red lines), and did not cross them. Furthermore, such a result provides an integrating relationship evidence among variables. Similarly, it is clear from the Figure A1 that each coefficient is also individually stable because no one is crossing the boundaries of the critical limits. Therefore, the above results indicate that the long-run ARDL (1, 2, 2, 2, 0, 1, 2, 2) model passes all the diagnostic tests.

Conclusion

The present study investigates the relationship between the real exchange rate and some macroeconomic variables in Algeria and contributes to the existing literature of Dutch disease through investigating its impact on the equilibrium real exchange rate performance over the period of 1990–2016. To do so, we rely on the ARDL, the ECM for the short-run and the OLS for the long-run coefficients. In fact, high oil prices provoke a large appreciation of the real exchange rate. And since oil rents are the main source of income for Algeria, and oil price movements determine a large part of it regardless the diversification of the economic activities, one may say that, theoretically, the Dutch disease occurs if we refer to Algeria's export sector. However, this study shows that although the oil prices and, thus, the corresponding revenues are improved, the evolution of the real exchange rate cannot be explained according to Dutch disease theory. The exchange rate is already influenced by the fiscal and the monetary policies, as it has approached its equilibrium value which means the absence of Dutch disease.

At the beginning of the research, we assumed two hypotheses. The first, that is, the shocks that influence the equilibrium real exchange rate do refer mainly to Dutch disease, has not been proven. However, the second, that is, shocks that influence the equilibrium real exchange rate in Algeria do not refer to Dutch disease, has been proven. Our results are consistent with those of some earlier studies such as, for example, *Djoufelkit (2008)*, *Derbal & Dekkiche(2011)*, and they are different from those of other studies such as *Chekouri & al.(2013).*

Our findings referring to the long-run estimates reveal that the equilibrium real exchange rate *Lreer* is highly elastic to the changes in its fundamentals. They strongly support that a 10 per cent increase in the share of employment in the informal sector produces a 3.1 per cent appreciation in the DZD real exchange rate. Yet, this finding is not enough to confirm the resource movement effect, particularly, under considerable rates of unemployment. Similarly, the terms of trade are significant in explaining the DZD real exchange rate movement. A 10 per cent improvement in the terms of trade, leads to about a 2.2 per cent appreciation in the real exchange rate. It is also suggested based on the model that the technological progress may have been the dominant source of persistent real exchange rate shocks. A 10 per cent improvement in the productivity as a proxy of the technological progress leads to a 0.45 per cent appreciation in the DZD real exchange rate in the long run which confirms *the Balassa Samuelson effect*. Also, the coefficient of the capital flows is significant and correctly signed. A 10 per cent increase in the capital flows leads to about an 8.5 per cent appreciation in the DZD real exchange rate. Finally, the coefficient of the government spending has the correct sign and is statistically significant. A 10 per cent increase in this variable, leads to an 8.9 per cent appreciation in the DZD real exchange rate. This implies that the proportion of the government spending on NTs is greater than of Ts.

Oil rent is highly significant with an unexpected negative sign, indicating that a 10 per cent improvement in oil rent leads to depreciate the DZD real exchange rate by almost a 2.2 per cent. In fact, the existence of such a relationship between the oil rent does not meet the necessary condition for the presence of the Dutch disease traditional form, the channel through which the excessive oil revenues affect the local producers. Likewise, the trade openness explains significantly, with a negative sign, the variation in the long-run real exchange rate. A 10 per cent increase in trade openness contributes to depreciating Algeria's real exchange rate by 1.79 per cent.

Accordingly, we cannot detect the major symptoms of Dutch disease, i.e. the appreciation of REER due to high oil revenues. The spending effect is not confirmed in Algeria over the period of 1990–2016 due to the state control of the exchange rate. Similarly, the resource movement effect is difficult to be proven due to the existence of unemployment. Therefore, these results are insufficient for such a purpose. Indeed, Algeria's real exchange rate has experienced a falling trend over the studied period due to the monetary authorities intervening, thus, it has not been affected by Dutch disease that assumes its appreciation.

In the short-run, the ECM sheds light on the adjustment speed from the short-run to the long-run equilibrium. The ECT reveals that about 184 per cent of disequilibrium errors are corrected within a year with an adjustment speed of 54 per cent i.e. Six and a half months. Moreover, based on the ECM estimates, all variables are significant in explaining the movements of the DZD equilibrium real exchange rate. The technological progress, the government spending and the capital flows are found to be major determinants with a significant positive impact on the real exchange rate in both long and short runs.

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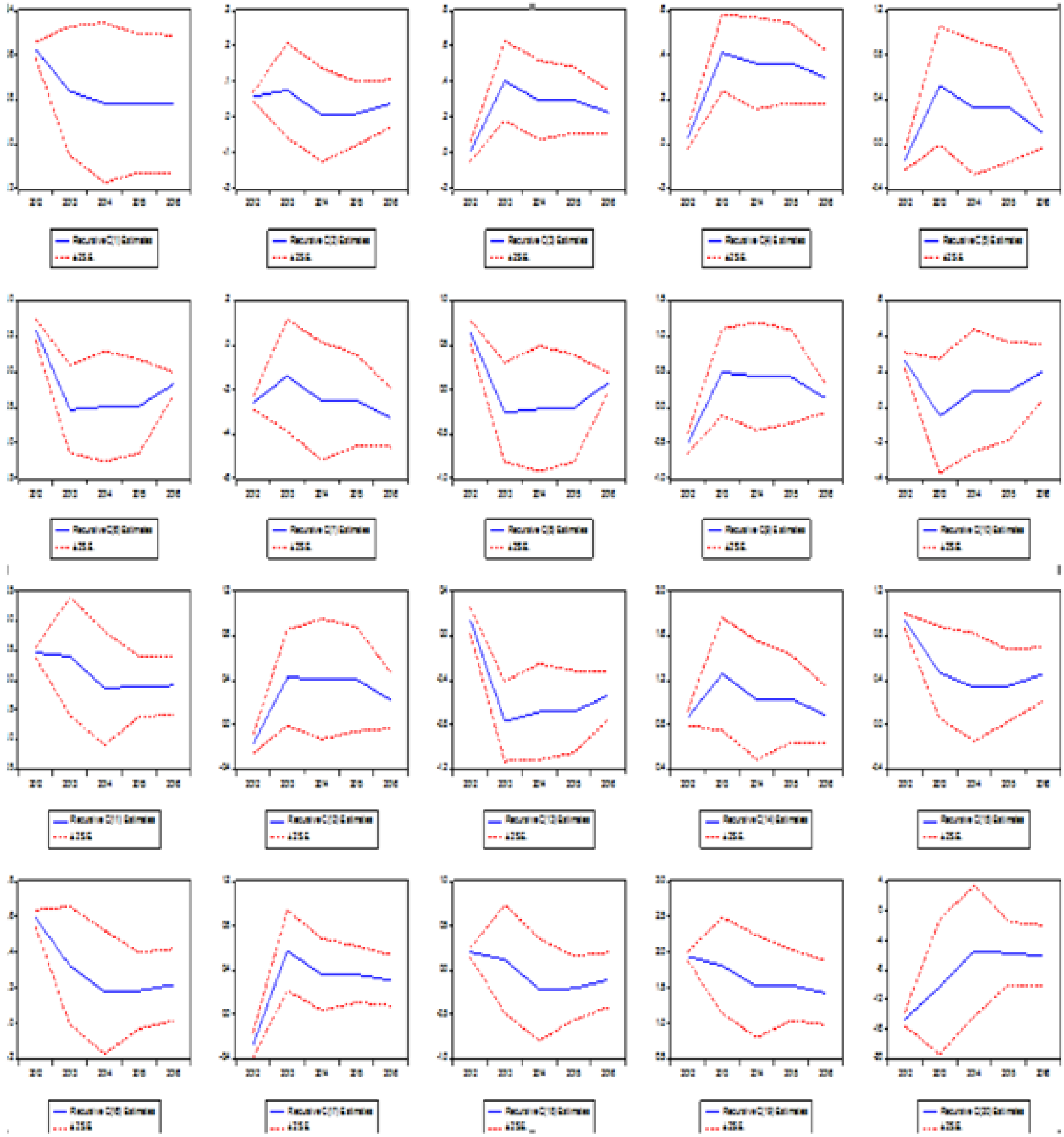
Appendix

Figure A1 : Recursive Coefficients



Authors' output using Eviews

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